

**Before the
Federal Communications Commission
Washington, D.C. 20554**

In the Matter of)	
)	
Amendment of Part 97 of the)	WT Docket No. 05-235
Commission's)	
Rules To Implement WRC-03)	RM-10781, RM-10782, RM-10783,
Regulations)	RM-10784, RM-10785, RM-10786,
Applicable to Requirements for)	RM-10787, RM-10805, RM-10806,
Operator)	RM-10807, RM-10808, RM-10809,
Licenses in the Amateur Radio Service)	RM-10810, RM-10811, RM-10867,
)	RM-10868, RM-10869, RM-10870

COMMENTS OF MARC RESSLER

INTRODUCTION

1. I have read the NPRM&O and over 3,000 comments filed in this proceeding, as well as a number of the Petitions for Rulemaking that led up to this proceeding. The issue of CW¹ testing has been an emotional one for years, and the language of some responses to this proceeding reflects the fervor on both sides. This NPRM proposes to eliminate Element 1 (Morse code testing) from all amateur radio license exams. What led to this was a number of Petitions for Rulemaking as a result of WRC-03 revising Article 25.5 of the International Radio Regulations², letting administrations (essentially countries) determine for themselves "whether or not a person seeking a license to operate an amateur station shall demonstrate the ability to send and receive texts in Morse code signals." In other words, while demonstrating Morse code ability is no longer *required* for an amateur license at any frequency by international agreement, this does not mean that countries are restricted from requiring amateur license applicants to pass a Morse code examination. The WRC-03 ruling was followed by a meeting of the Administrative Council of the International Amateur Radio Union (IARU) in Amsterdam in September 2003, which passed a revised Resolution 01-1 "concerning the Morse code"³. The Administrative Council, while stating that Morse code is "an effective and efficient mode of communication used by many thousands of radio amateurs," resolved "IARU policy is to support the removal of Morse code testing as a requirement for an amateur license to operate on frequencies below 30 MHz."

¹ The term 'CW' is an abbreviation for continuous wave but in this case refers to International Morse code telegraphy emissions as per § 97.3(c)(1).

² World Radiocommunication Conference Final Acts (Geneva, 2003) (WRC-03 Final Acts), Article 25

³ <http://www.iaru.org/ac-0309min.html>

2. It was easy to understand why most, but not all, Technician class licensees filing comments favor the removal of Element 1, but I must admit that the number of long-time Amateur Extra class licensees that also agreed with the proposals surprised me. It annoys me that some people have already declared that the NPRM is in fact law before these proceedings are over.⁴ A review of all this information has led me to the difficult decision that it is probably time to allow access to the frequencies below 30 MHz without requiring a CW test. This does not mean I believe that Element 1 should be eliminated, or that the history and value of CW should be ignored or denigrated in this process and I will explain my problems with the conclusions reached in the NPRM&O and with some of the Petitions for Rulemaking that led up to it in addition to previous rulings.

BACKGROUND

3. The Commission has been de-emphasizing the use of CW for quite some time. In the *Codeless Technician Decision*, it was stated⁵ “We do not foresee that telegraphers will be in as great demand by future systems as will electronics and communications experts”, and in the *Restructure Report and Order* stated⁶:

We are persuaded that because the amateur service is fundamentally a technical service, the emphasis on Morse code proficiency as a licensing requirement does not comport with the basis and purpose of the service. We note, moreover, that the design of modern communications systems, including personal communication services, satellite, fiber optic, and high definition television systems, are based on digital communication technologies. We also note that no communication system has been designed in many years that depends on hand-keyed telegraphy or the ability to receive messages in Morse code by ear.

The *Restructure Report and Order* reduced the requirement for CW testing to 5 words per minute, minimizing the effort necessary to pass the test.

4. The NPRM⁷ states that communication by Morse telegraphy is a recreational activity that reflects operator choice and preference, rather than necessity. Perhaps it is time to mention the thing that is not referenced in the rules or in any of these proceedings. Most members of the Amateur Radio Service consider this is a hobby – granted one that is regulated by Federal law – but a hobby nonetheless. With the exception of emergency communications, all communications modes chosen or preferred

⁴ In 'Electronic Latitude, the electronic version of Latitude 38, a Northern California sailing and marine magazine, the headline for October 14th was “The Time to Get Your Ham License Is after the Start of the Year” where they reported that “Gordon West, the Newport Beach-based man who knows everything about ham radios, particularly for boats, confirms that as of January 1, applicants for general class ham licenses will no longer need to pass a Morse Code test.”

⁵ PR Docket 90-55 “In the matter of Amendment of Part 97 of the Commission's Rules Concerning the Establishment of a Codeless Class of Amateur Operator License - Report and Order” at 13 referring to the NCI filing.

⁶ WT Docket No. 98-143, FCC 99-412, “1998 Biennial Regulatory Review -- Amendment of Part 97 of the Commission's Amateur Service Rules – Report and Order” at 30.

⁷ NPRM&O at 6.

are done as part of *recreational* activities. The essential nature of most amateur contacts is person-to-person communications of a personal or technical nature. Because of this, modes that support such communications (phone, CW, keyboard) are the ones generally preferred.

5. Although I have no doubt that there are some people for whom it is impossible to learn the Morse code, the vast majority of respondents who want to eliminate Element 1 indicate that they just don't want to, with a few indicating they could readily learn or already know the Morse code but refuse to take the test. Considering that only new entrants and existing codeless Technician class licensees need to pass Element 1 to get a General or Amateur Extra class license, it appears that they are in general uninterested. To emphasize this point I note that Richard Davidson⁸ reported "In the years since the restructuring of the Amateur Rules became effective on April 15, 2000, fewer than two percent of the elements tested in my experience as a Volunteer Examiner included Element 1 for Morse code competency at a speed of 5 words per minute." In addition, an examination of amateur radio station statistics⁹ shows that at the time of the *Restructure Report and Order* the total¹⁰ number of Technician licensees was 337,870. Within 18 months that number had been reduced by over 28,000 while General class licensees had grown by almost 27,000. Based on the low rate of Element 1 examinees, it is easy to believe that most of that change was due to previous Technician Plus licensees upgrading by taking the General class written exam, rather than Technicians passing both a CW and written test.

6. I suspect the amount of study time necessary for someone with no technical background to pass any of the written tests does not differ much from the study time needed to pass Element 1, and it bothers me that people state that they do not have the time to learn Morse code. Bothers me, but does not surprise me. I work in a technical field and for years tried to get people interested in communications in my building to get an amateur license. The standard excuse always was "I don't want to take a CW test". So, once the codeless Technician class was announced, I went back to some of these people and told them now they could get a license without having to know Morse code. They did not even go to take a test after I lent them a study guide. In the last year, I taught an amateur radio class at work, designed to provide students with general knowledge for any of the three written examinations. They were provided copies of Part 97 and the question pools for all three exams as well, although these were not covered in class. Understand that these were all scientists and engineers and two of them were from the group of people who I tried to get licenses earlier. One of the two dropped out of class before it concluded, and the other never sat for an exam, even though he passed a sample

⁸ Comments of Richard Davidson

⁹ www.ah0a.???

¹⁰ Technician and Technician Plus were combined in the ULS system in 1999 so it is no longer possible to separate them in the FCC statistics. Those holders of Technician Plus licenses (who had passed the CW exam) still had access to the Novice frequencies and retained credit for having passed Element 1.

examination I gave everyone in class. This “inertia” is why I believe everyone is mistaken if they think eliminating Element 1 will result in a large influx of new licensees. Yes, it *may* result in a large number of upgrades, but I am not even sure of that. After all, it would appear that only 20% of the Technician Plus licensees upgraded to General when “all” it involved was a written test. However, considering the statistics above, it appears that elimination of CW testing for entry into the HF bands is in the best interest of the future of the service.

7. NCVEC claims that the telegraphy examination is stressful for the applicant.¹¹ I am sure that *any* examination is stressful to the applicant, regardless of whether it is written or not. It is amazing that the NCVEC claims¹² that, after 20 years of operation, it is difficult to compose a suitable Element 1 test that is “realistic”. By now, the 14 VECs should have accumulated a large number of these simulated messages. About 20 years ago I wrote a program for a Commodore 64 that generated pseudo-random practice messages including realistic call signs, names, weather, occupation, etc. and would send them in Morse code through the monitor. While it did not fully meet the requirements of §97.503 (a) and §97.507 (d), it would not appear to be difficult to generate a program that did. Similarly, it is hard to believe that any specialized equipment is necessary to present the examination to applicants, or that doing so would somehow disturb other applicants. An MP3 player and a pair of headphones is a small, inconspicuous package to act as a backup in any case.

CW IS NOT OBSOLETE

8. The NCVEC¹³, NCI¹⁴, and numerous commenters have called Morse code obsolete, outdated, and archaic, often noting that modern communications systems no longer employ CW. The amateur service is not a commercial service or a military service, and has no requirement to follow the operational and financial considerations that drive these other services. Some commenters have stated that taking the element 1 examination is equivalent to taking a motor vehicle operator's test that requires expertise in the use of a buggy whip¹⁵, horse¹⁶, bicycle¹⁷, or hitching oxen to a cart.¹⁸ One actually has to wonder what many commenters would say if it weren't only five years into the 21st century, as this seems to be a recurrent theme. All of these comparisons are obviously disjoint from operating a motor vehicle, while knowledge of Morse code is not disjoint from operating an amateur

¹¹ NCVEC first petition, RM10787 at III

¹² *Id.* at VI

¹³ *Id.* at I and II

¹⁴ No Code International petition RM-10786 at 9 and 21.

¹⁵ Comments of Ronald W. Frazier.

¹⁶ Comments of William Leahy.

¹⁷ Comments of Raymond E. Thompson. I must point out that the author is a member of the League of American Bicyclists, an organization that is even older than the ARRL.

¹⁸ Comments of Charles Carter.

station. Let me propose a more reasonable automotive example. It used to be that it was required to take a motor vehicle operator's test in a standard transmission (stick shift) car – since that was all that was around. In 2002 only 10% of the cars sold in U.S. had standard transmissions, compared to 15% of the cars sold in the U.K. having an automatic transmission¹⁹. Imagine my surprise (and concern) a few years ago as I watched someone who was obviously unfamiliar with standard transmissions try to drive my car²⁰ on a treadmill system for check auto emissions. Imagine the consternation that renters face in Europe when they discover they may have to drive a standard transmission automobile. Washington, DC (home of the FCC) still requires applicants to demonstrate hand signals as part of a license exam, while still using electric signals during their road test. Why? Because bicyclists and scooters are still required to use hand signals and if motorists cannot understand them, they may very well consider an extended left arm to indicate “go around” leading to an accident. These are not anachronisms, any more than CW is, but rather are examples of long-lived standards that still have value.

9. The fact remains that CW is demonstrably the second most popular operating mode in the amateur service. The ARRL often conducts polls on its web site.²¹ These polls are not scientific and reflect the opinions of only those users who have chosen to participate. Thus, the results cannot be assumed to represent the opinions of the amateur community as a whole. In a March 10, 2003 poll of 3073 users to gauge the percentage of operating time using CW, 32.6% of respondents said they did not operate CW at all, while 44.0% responded that a majority of their operating time was spent using CW. Other indicators of CW activity are the numerous contests that are offered throughout the year by various organizations. In 2005 the ARRL sponsored, amongst other things, the ARRL International DX Contest – SSB and CW modes, and the RTTY Roundup (using digital modes of Baudot RTTY, ASCII, AMTOR, PSK31, and Packet). The number of entrants for these events was: phone – 2057, CW – 2570, and digital – 923. These events were on different weekends, and these numbers only indicate those who filed entry forms. Two other contests from 2004 (IARU HF World Championship and ARRL 10 meter Contest) supported phone, CW, and mixed modes (both phone and CW) on the same weekend. For these contests the entries were: 10 Meter CW – 552, phone – 546, mixed – 614; and IARU CW – 770, phone – 576, mixed – 593. Perhaps a better indicator is the maximum number of contacts made in a contest, as this eliminates the issue of whether entries were sent in and is more a measure of the number of users. The results from the 2002 CQ Worldwide Contests indicate that for phone the maximum number of contacts obtained on any band was 5117, while on CW it was 4148. These statistics still suffer from the fact that the contests were held at different times. In the

¹⁹ Eric Mayne “More fans of stick shift switch gears”, The Detroit News Autos Insider, Sept. 13, 2004

²⁰ Contrary to any apparent evidence in this document, the author is *not* a Luddite. As anyone who has driven sports cars will tell you there is a lot more control available in a standard transmission.

²¹ <http://www.arrl.org>

article²² "Is Morse Code Dead?" by Walter B. Fair, Jr., Mr. Fair collected statistics on operating mode by examining the data available from the DX Cluster Database. This data represents reports from around the world as to where in frequency DX (long distance) stations are operating at any particular time. As can be seen for the results from the last few years, and from the results mentioned above, CW is easily the second most common mode of operation by a large margin.

Year	%CW	%SSB	%DIG
1997	38.7	56.7	4.6
1998	42.1	52.2	5.8
1999	45.0	49.7	5.3
2000	43.1	51.1	5.8
2001	45.0	48.7	6.3
2002	43.2	48.5	8.4
2003	43.7	48.8	7.5

WHY CW

10. In addressing the value of CW the Commission has focused on only one of the basic principles of the amateur service, namely advancement of the radio art²³. The complete list of the principles²⁴ is:

- (a) Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications.
- (b) Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.
- (c) Encouragement and improvement of the amateur service through rules which provide for advancing skills in both the communications and technical phases of the art.
- (d) Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.
- (e) Continuation and extension of the amateur's unique ability to enhance international goodwill.

11. Note that none of these principles are *requirements* for a license holder as pointed out in the NPRM²⁵ with regards to emergency communications. However, they are the basis of the amateur service. The NPRM²⁶ and *Restructure Report and Order*²⁷ have both stated "that most emergency communication today is performed using voice, data, or video modes, and that most amateur radio operators who

²² Available at <http://gacw.no-ip.org/w5alt.html>

²³ NPRM&O at 3 and 17. See also *Restructure Report and Order* at 2 and 25

²⁴ § 97.1

²⁵ NPRM&O at 4 and 20.

²⁶ *Id* at 20.

²⁷ *Restructure Report and Order* at 13.

choose to provide emergency communication do so using voice or digital modes of communication, because information can be exchanged much faster using modes of communication other than telegraphy.” While I suspect that most emergency communications is conducted by voice, and that the reports on the emergence of data communications indicate great support to the agencies that amateur radio works with in disaster situations, I have seen no evidence presented to these facts in the record or to any indication that the prevalence of video exceeds that of CW. In a local disaster area, the major means of communications support is typically by VHF/UHF FM as amateurs with mobile or hand-held radios can report on conditions and need for equipment/supplies to local emergency operations centers. Communications to other parts of the country outside the disaster area are then handled on HF. Here, a large mass of formal message traffic may be best handled by digital means, but it is not yet in use everywhere, and requires extra equipment that may not be present in the early stages of an emergency deployment. If the Commission has never heard a phone network passing traffic, they may not realize that every separate initial is sounded out in phonetics, as is every unusual word and the majority of addressing and signature blocks. This is not an issue in CW as it is also a digital mode, the first digital mode in fact, and every character is uniquely recognizable, making it possible to handle messages faster than by voice. This is not to indicate that CW is the best or only solution as the ARRL notes²⁸ “The National Traffic System is not dedicated specifically to any mode or to any type of emission, nor to the exclusion of any of them, but to the use of the best mode for whatever purpose is involved.”

12. CW remains the simplest mode, one that can be understood by both human and machine, and can be generated by simple means. Simple low-power CW radios are inexpensive, allowing children and those of modest means an opportunity to own their own radio, and they can be operated from batteries for long periods of time, allowing operations from locations all over the world. The existing set of internationally recognized Q-signals and abbreviations allows people who speak different languages to converse without need of translators, thus enhancing international goodwill. The QRP²⁹ community has been producing (as individuals, one or two person companies, and clubs) a number of low power radios and accessories, mostly in kit form. The simplest of these are by necessity CW radios, although DSB, SSB, and PSK versions have been produced as well³⁰. Instructions

²⁸ <http://www.arrl.org/FandES/field/pscm/sec2-ch1.html>

²⁹ The international signal QRP means “can you reduce power” and has been adopted around the world to indicate radio communications at power levels below 5 watts (10 watts PEP for SSB). QRP clubs exist around the world with several in the United States.

³⁰ This is not to indicate that all of these kits are necessarily stripped of features or languishing in the past. I recently completed a 4-watt QRP CW kit that was mostly constructed from surface mount components. It incorporates a microcontroller and a direct digital synthesizer (DDS) to provide a multiband transceiver that fits into an Altoids tin. The operator interface is provided by sending Morse code information to the headsets and receiving Morse code commands from the keying paddles. This is not a toy, but a full functioning single conversion transceiver with an IF bandwidth

for the kits are provided on CD or are available on the web, along with instructional material. These types of activity lead to advancing skills in the technical phases of the art, the expansion of the existing reservoir of trained technicians and electronics experts, and leads to advancement of the radio art. The Commission has stated³¹ that the amateur service is fundamentally a technical service and that our goal should be to attract technically inclined persons, particularly the youth of our country, and encourage them to learn and to prepare themselves in the areas where the United States needs expertise. These are basically the goals espoused by the NCVEC who note “There is no better place for a beginning engineer to experience the hands-on training and knowledge gain the assembling and operating a modern Amateur Radio station provides.”³² These simple kits and instructional materials provide the basis of classroom lessons and are one of the best ways to capture the interest and develop the technical skill set of the youth of this country while introducing them to amateur radio. The concept that it is not necessary for licensees to understand electronics and other technical subjects in order to properly operate commercially manufactured equipment³³ is an anathema to the amateur service.

EXAMINATIONS AND LICENSE CLASS

13. The NPRM at one point³⁴ maintains that examinations are given to meet the requirements of the *Radio Regulations* that administrations verify the operational and technical qualifications of any person wishing to operate an amateur station. Yet in other places³⁵ it is stated that the only purpose of the examination is to determine whether a licensee can properly operate an amateur station. The current regulations support three different classes where additional frequency privileges provide an incentive to upgrade³⁶. If the only reason for the examinations are to determine if one can properly operate an amateur station, then it is unclear why there is anything more than one class of license. If there no need to examine technical qualifications, then there is no need for an amateur service, as communications can be provided through any of the number of other services the Commission regulates. In either case, the NPRM does not explain how an operator is expected to show he or she can properly operate a CW-only radio without having passed element 1. If, on the other hand, the basic premise behind the three-tiered license structure is to provide additional privileges in frequency bands and emission types with improved technical and operational experience, then the General Class license provides access to HF frequencies and to all available modes of operation.

of 400 Hz, which has already allowed me to contact stations as far away as Moscow. The concept of using Morse code as an interface has a long history in the QRP community as a way to save both the power and the space necessary to support other forms of human interface.

³¹ *Restructure Report and Order* at 30.

³² NCVEC second petition, RM10870 at 15

³³ *Restructure Report and Order* at 44.

³⁴ NPRM&O at 15. See also § 97.503(b).

³⁵ *Id.* at 37

³⁶ *Id.* at 8. See also *Restructure Report and Order* at 13.

14. A number of petitioners³⁷ and commenters have mentioned that CW is just another mode that deserves no special consideration or testing and the NPRM agrees.³⁸ In fact it is mentioned that the rules do not require licensees to use or maintain proficiency in telegraphy. However, it used to be required that an applicant for renewal of a license attest to the fact that they could still copy CW at the speed required for their license and that they had conducted on-air operations for some period of time in the previous six months or previous year. It is unclear why these requirements were dropped from the regulations. While it may be true that the one time passing of a 5 word per minute examination does not ensure future proficiency, at least the licensee is exposed to Morse code. One problem that remains is CW cannot be tested the same way as other modes, since it is actually an acquired skill.

15. Applicants for the General Class license have to pass an examination that is drawn from a pool of 432 questions. Passing this examination allows access to HF frequencies and all modes of emissions. The question pool has 6 questions related to CW operations, 20 questions on digital (RTTY and PSK) operations, 1 on image communications, and 44 questions on phone operations, so one must assume that the General class license is much like a driver's license – although one is allowed to drive a vehicle on the road, the operator is not necessarily completely skilled, as they have not been tested on everything. The Amateur Extra Class license provides exclusive rights to 175 kHz of HF spectrum, of which 100 kHz is used for CW.³⁹ The Amateur Extra examination pool contains 5 questions on CW operations, 35 on digital modes, 25 on image modes, and 36 on phone operations. Numerous commenters have decried the fact that no other mode is tested like CW is while the NPRM states⁴⁰ “we should treat Morse code telegraphy as a communications technique with the same standing as other modulation techniques in the amateur service licensing requirements.” I put it to you that elimination of Element 1 would not treat CW with the same standing as other modes, but rather would seriously degrade it, and brings up the troubling question of how one is ever expected to properly operate a station in CW without appropriate training or testing. I recommend that Element 1 be retained for the Amateur Extra examination as appropriate to ensure the applicant can perform properly the duties associated with the privileges of the license sought considering the exclusive CW band allocation.⁴¹ It should not be surprising that the small question set for CW is the current state of affairs as the NCVEC, through the three-member question pool committee (QPC), is

³⁷ First NCVEC at II, <http://www.nocode.org/>.

³⁸ *Id.* at 19.

³⁹ Although other narrow band modes are allowed in the Amateur Extra CW segments, the U.S. and worldwide band plans typically designate these frequencies for CW only.

⁴⁰ NPRM&O at 19.

⁴¹ *Codeless Technician Decision* at 27.

responsible for question pool, and their opinions on Morse code have been filed in this and previous proceedings⁴².

16. The elimination of Element 1 also poses the problem that there is no longer an entry level path into HF. Currently, one can pass the Technician written examination and Element 1 and obtain the same HF privileges that Novices have. The Commission has denied the petitions for rulemaking requesting new entry-level classes and does not seem to appreciate how much of a challenge to a non-technically trained individual or youth the examinations are. If we are to provide a path to advance both operating and technical skills to our youth, then we need something that fits with their current education (and financial needs). I have great personal interest in this point, as I was a Technician for 19 years. During most of that period the Commission expected me to be an experimenter, not a communicator, and I was restricted to the VHF/UHF bands in the days before FM and repeaters were popular. A change in the regulations brought me Novice privileges and the ability to limited operations in the HF bands. This allowed me to improve my operator skills and I eventually upgraded, by then having acquired the technical background needed through school and work and experience gained through building equipment at home.

PROCEDURAL MATTERS

17. The Commission's ability to prognosticate is likely no better than mine, and in either case is cannot be proved in advance. However, it is my belief that the complete elimination of Element 1 will mean that future amateur licensees will have no exposure to CW as part of the examination process. Why would the QPC keep the few questions they have left in the question pools if there is no Element 1 test? This would eventually result in a decrease in the number of operators using CW, as there would be little reason for one to think about learning CW if there was no way they could experience it. I therefore believe the Commission is wrong in assuming there will be no impact on publishers of Morse code training materials.⁴³ In addition, the NPRM ignores the impact on the producers of CW-only transmitters and transceivers. Many of these are small business that should fall under the requirements of the Regulatory Flexibility Act.

SUMMARY

18. The goal of this NPRM is ostensibly to:⁴⁴

- (1) encourage individuals who are interested in communications technology, or who are able to contribute to the advancement of the radio art, to become amateur radio operators

⁴² *Codeless Technician Decision and Restructure Report and Order.*

⁴³ NPRM&O at 50.

⁴⁴ *Id.* at 3.

- (2) eliminate a requirement that we believe is now unnecessary and that may discourage amateur service licensees from advancing their skills in the communications and technical phases of amateur radio; and
- (3) promote more efficient use of the radio spectrum currently allocated to the amateur radio service.

Item (1) is already provided for by the Technician Class license, but I can see the future benefit to the service of allowing a General Class examination that does not require Element 1. For item (2) I hope I have shown the value of continuing the use of Element 1 for the Amateur Extra applicants and Technician Class licensees, as well as the value of CW in developing technical training, especially for the youth of this country. Item (3) is completely out of place here as CW is one of the most bandwidth efficient modes that exist. The late Ray Petit proposed a coherent CW (CCW) system in the September 1975 issue of QST. This was a digital filtering approach in the days before PCs and allowed a frequency stabilized 12 words per minute CW signal to be received in a 9 Hz bandwidth, with regenerated audio showing no signs of ringing. This system was adopted by a number of QRP enthusiasts, as it was easily applied to the then prevalent direct conversion receivers in most QRP transceivers and allowed approximately a 20 dB improvement in signal-to-noise ratio. Such a system was used to establish communications between the West coast and Japan with a power of 100 mW. Properly formed CW characters are extremely conservative of spectrum.